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ABSTRACT

The purpose of this study was to determine what representations of content existed in a secondary environmental science class and what happened to those representations during curriculum occasions. Initial data construction involved attention to what was actually going on during class sessions. Following this, a reanalysis of the data corpus with specific focus questions allowed the writing of descriptions of each occasion for content, and these descriptions became the units of analysis in the study. Some class sessions involved occasions for two or three pieces of content being tracked; others involved just one. These occasions were analyzed separately. Also, an analysis was conducted across occasions in order to track what happened to pieces of content across time and sessions. The findings that emerged from the analysis across occasions was especially informative and useful. A major piece of content tracked was "niche," a fundamental construct in environmental science. The development of niche, which spanned 16 class sessions, began on the first day, moving from an exploration of roles, especially the powerful roles humans have in the ecosystem, and going on through the various representations of content of niche, population change, and entropy as each evolved over the course of instruction. The findings indicate that instruction when studied in the contexts in which students experience it, is not an inert instructional variable, but rather that the dynamic nature of content can exist in an experienced curriculum. Therefore, assumptions about what the content is in a classroom may be vulnerable to much variation. (Contains 20 references). (AA)

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CONTENT REPRESENTATIONS IN A SECONDARY
ENVIRONMENTAL SCIENCE CLASS

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2
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INTRODUCTION

This paper is about content and how it was represented in a secondary environmental science classroom. Various pieces of content were tracked across time and sessions as representations in the curriculum experienced by students and teacher. It is the tracking of content across curriculum occasions which makes this study unique and informative.

BACKGROUND AND THEORETICAL FRAMEWORK

Research on content in science curricula is not a new line of inquiry in the educational research community. Several studies have involved questions about science content, what students know about it before and after instruction, and what teaching behaviors and curricula seem to be associated with learning it. Walker & Schaffarzick (1974) conducted an extensive review of experimental studies which compared achievement on subject matter between students using traditional and more innovative curricula. Their results reveal some interesting relationships. Walker & Schaffarizk describe their findings in this way:

We reasoned that if the innovative curricula were substantial improvements over traditional ones then these experiments should show a consistent advantage for students using the innovative curricula. The pattern of results we found in the reports we read seemed at first to show such a result. But, a more thorough analysis showed that innovative curricula were superior only in their own terms. More precisely, these studies showed that students using different curricula in the same subject generally exhibited different patterns of test performance, and that these patterns generally reflected differences in content inclusion and emphasis in the curriculum. (p. 83)

Findings from the extensive Beginning Teacher Evaluation Study (BTES) also suggest that what students are required to do with the content of the curriculum has significant effects on what they learn (Fisher, Berliner, Filby, & Marliave, 1978). Academic learning time was significantly and positively associated with student achievement. That is, students who spent time successfully engaged with content were also successful on measures of academic achievement.

Taken together, the results of these two studies yields a finding about curriculum which grounds the theoretical development of this study. The content which students learn seems to be closely associated with the nature of curriculum occasions in which they engage. It is these occasions, during which students come to deal with content, that provides the unit of analysis for this interpretive study of content in a classroom.

The focus on curriculum occasions in classrooms is demonstrated by Doyle's work (1983, 1986). He has used the construct of task as a framework for studying the context in which academic work is accomplished. Doyle argues that classroom dimensions, such as accountability and history of instruction, fundamentally shape the work which students are required to do, and thus effect what students learn about content. Sanford (1987) used the task framework to study higher cognitive level learning opportunities and associated conditions of management in junior high science classrooms. She found that the classroom

dimension of accountability was strongly associated with students taking their work seriously, yet teachers used "safety net devices" to keep student failure to a minimum. Studies such as these draw attention to the complexity inherent to classrooms and instruction. Furthermore, findings from studies such as these engender questions about the ecological validity of studying content isolated from the curriculum occasions in which it is embedded.

Few science education studies have investigated the nature of content in those occasions in which it is embedded as curriculum is accomplished. Yet findings from such inquiry would seem to provide valuable information in considering the effects of curriculum and instruction. This paper presents the findings of portions of a study conducted to track content in the curriculum occasions of an environmental science class. Specifically, this paper is focused on the following questions:

What representations of content exist in this curriculum?

What happens to the representations during curriculum occasions?

METHODS

The study was conducted in a secondary environmental science class taught by myself during the 1989-90 school year. Lampert (1986) and Roth (1989) set precedents for the teacher-researcher dual role in their studies of student learning in math and science classrooms respectively. The data corpus included audio tape recordings of all class sessions, student interviews on two

occasions, post-class teaching notes from each session, the text, teacher lesson plans, and samples of student work and exams.

Data was constructed according to guidelines suggested by Spradley (1980) and Erickson (1986). Initial data construction involved general attention to what was actually going on during the class sessions. Then, a re-analysis of the data corpus with specific focus questions allowed me to write descriptions for each occasion for content. An occasion for content was described as a context in which a piece of content was dealt with in the experienced curriculum. Often times pieces of content changed or "evolved" within an occasion. The occasion sometimes consisted of single tasks and at other times the occasion for a piece of content consisted of parts of two or three class sessions. These occasion descriptions became the units of analysis in the study. Some class sessions involved occasions for two or three different pieces of content being tracked. Other sessions consisted of just one occasion for content. These occasions were analyzed separately in order to determine why representations within occasions existed as they did. Also, an analysis was conducted across occasions in order to track what happened to pieces of content across time and sessions.

FINDINGS

As with any qualitative study, it is difficult to communicate within a few pages all the data that warrants the claims in the findings. Therefore, I shall describe the data of

some typical occasions for content from this study. The analysis was conducted at two levels, the first within occasions and the second across occasions. The following discussion of findings is organized around the analyses at those two levels. Not all occasions for content which were studied will be discussed in this paper. Nor will all pieces of content tracked across occasions be discussed. Rather, the following discussion presents typical occasions and the patterns within and across occasions which came to be the findings.

Within Occasions

In order to follow the general pattern of what happened to pieces of content within occasions, the reader is advised to review Figure 1. After some beginning content was represented (left side), the general pattern was that questions were asked about the content. The types of teacher questions and the points in the discourse where they occurred determined whether another representation emerged. Notice on Figure 1 that it was possible for the content to return to the form originally represented as information in the reading or a handout. In such cases, new representations did not evolve. This regularly occurred when students took the multiple-choice recall type quizzes at the beginnings of several sessions. During a quiz occasion in session 2, for example, students were given multiple choice answers to choose from for questions such as: "An example of a resource that can be used at a rate exceeding its sustained yield is ____." "Each of the following is an example of output

pollution control EXCEPT ____." The questions were a reiteration of the information represented in the reading assignment. Content change of this nature corresponds to the full-circle movement on Figure 1. Correct responses to the quiz questions simply re-represented the original form of content.

More often than not, however, the occasions consisted of a rerouting of content through the teacher and students as new representations were constructed during question, comment, and discussion episodes. This corresponds to the right side of Figure 1. An occasion during session 13 is especially illustrative of this pattern.

The beginning representation in the occasion for niche was "descriptions of two people." The students had prepared niche descriptions for 17 year-old male and female students, one of which was vegetarian and the other not. These representations of niche as descriptions remained unchanged for several minutes of class as discussion ensued about different aspects of what the students had written. Later, the representation of niche changed due to a different line of questioning which the teacher (myself) had inserted. I drew on the board a diagram of a person fishing off the bank of a lake. In and around this lake were several organisms and also pointed out were the different biogeochemical relationships represented by the diagram. I said to the students, "Tell me what to do to this diagram in order to summarize what this chapter was about." The students told me to add several lines and they proceeded to tell why these lines were

appropriate. Finally, I stopped and claimed that the picture, with all these lines, was a "real mess." I asked, "Why do we spend so much time trying to understand such a complex messy thing?" Students said that we needed to recognize and understand cycles and relationships. One student said, "But, that won't clean up the messes we've made." I asked what such an understanding does help to do. The students' general response was that knowing about the relationships help us to avoid making more messes in the cycles. I asked, "If all these relationships interseected HERE (pointed to a spot on the diagram). . . what do we call that?" Several responded, "a niche." I further asked, "and HERE?" "A different niche," many said. "Yes," I said, "the existence of these complicated relationships establishes a niche." At this point I laid a picture of an unusual looking organism on the overhead projector and directed a discussion about its adaptations and possible inferences one could make about the organism's niche.

What began as a representation of niche as descriptions of organisms, later changed to niche as an intersection of complicated relationships, and finally as an inference one makes about organisms based upon their adaptations. The emergence of multiple representations of a piece of content was a predominant theme within occasions for content of all types. Furthermore, these multiple representations often occurred during episodes of discussion, questioning and discourse. This episode from an occasion for niche illustrates at least two of the patterns found

from the analysis of many individual occasions for content. The patterns are summarized below:

1. Students were held accountable for knowing some beginning content, often from the text or some other assigned reading.
2. At times this beginning, "expert" representation was simply repeated during question and answering occasions.
3. More often than not, the beginning representations were used as starting points for the construction of additional representations.
4. These additional representations often appeared during curriculum occasions in which teacher questions, student responses, and student questions structured the discourse.
5. A combined retelling/redirecting of "expert" representations occurred during occasions for evaluation or occasions directly associated with evaluation.
6. The teacher's recognition that multiple representations of a piece of content had been accomplished seemed to be associated with a halt in the changes in that piece of content.

Findings number 3 and 4 are illustrated fairly well by the occasion for niche described above. Finding number 1 was found consistently at the beginnings of occasions for content. Students were held accountable for coming to the occasion with a familiarity of some information regarding the content. The likelihood of quizzes played a major role in this scheme of accountability for some beginning content. Finding number 2 was based on several occasions in which the teacher led discussions of the reading or students took quizzes over the reading material for the day. In another part of the larger study (not included in this writing), it was found that my teaching knowledge of content representation in this class included a belief that

students needed an understanding or at least a familiarity with an "expert" representation of a piece of content in order to begin thinking about alternative or multiple representations. This belief appeared to be also associated with finding number 6. Finding number 5 was associated with my beliefs and concerns about evaluation coupled with my theories of content as multiple representations.

Across Occasions

The findings which emerged from the analysis across occasions were especially informative and useful in constructing answers to the basic inquiry questions. This suggests that attention to time and how it is spent in classrooms is an appropriate variable to consider in studies of curriculum, and especially content.

The following discussion is organized around the tracking of one piece of content across occasions. In a sense, what follows is the report of a case study of content. Niche was the piece of content tracked and chosen for inclusion in this writing. Niche is a fundamental construct in an environmental science or ecology course. Additionally, the tracking of niche is illustrative of several patterns which emerged as similar analyses were conducted on other pieces of content.

A Case of Content: NICHE

The development of niche began on the first day of class. It is its "longevity" across occasions which make niche an especially interesting piece of content in this study. During

sessions 1 and 2 the class considered the different philosophies which exist about the means by which pollution can or ought to be controlled. These philosophies are generally separated into what is called input or output philosophies. Input philosophies are inherent to those who favor avoiding the production of pollutants, while output philosophies represent the traditional response of dealing with unwanted wastes as best we can. The content feature of the occasion which bears on the construct "niche," however, is that the discourse during these occasions was in part about the roles that humans take in controlling pollution. The key word in the preceeding statement is ROLES. From early on, the powerful roles which humans have in ecosystems was represented. This idea of roles was carried into sessions 3, 4, and 5. In a session 3 occasion, students read about and discourse ensued about the different viewpoints on human roles offered by the cornucopian and neo-Malthusian environmental perspectives. In sessions 4 and 5 occasions, human roles were further considered as the history of human impact on earth was studied. The notion of the impact of those roles was also of concern during session 7.

The next occasion in which the construct of roles appeared was during session 10. This was an exam session. Two questions from the exam which are in some way related to the idea of human roles are shown below (Session #10, Exam, pages one-two):

Question #1: According to the third principle given above, the world creates its own disorder all the time no matter what we do. If that is true, why bother changing our lifestyles at all? It

seems that our environment is doomed to disorder anyway.

Question #3: Use good "thermodynamic sense" (principles 2 and 3 above) to choose one of the dinners below. Tell why you made that choice.
(Choice) Roast beef from a grass-fed steer OR fresh halibut from an ocean fisherman's catch.

There were other questions on the exam which also required a link to the idea of roles.

It was not until an occasion during session 12 that the construct of NICHE was formally introduced. This was accomplished through the students' reading of the author's explanation of biogeochemical cycles, energy relationships and intereactions in ecosystems. Niche was represented as an "occupation" which an organism has in the system of which it is a part. Further, the author represented niche as a "description of all that a species needs to survive and reproduce," and as "a lifestyle" of an organism (see Miller, pp. 67-68). Students were also introduced to the idea that there are different types of niches, generally described as generalist or specialist, depending upon the specificity of the organism's situation in "life." Later in this session after reviewing what niche meant according to the author, I asked the students to describe a penguin's niche. There were several responses and I summarized finally by saying that niche would be "anything affecting the livelihood of an organism or the livelihood of competing organisms." Then I told the students about allozymes and electrophoresis, an electrochemical means of comparing similar enzymes from different individuals. I explained what it was, how

it worked and how it explained the great deal of variety in a population for that one enzyme. This led to questions and discourse about the significance of studying allozymes for evolution. Further, that genetic variety may help to explain why similar organisms may occupy different niches yet appear to be much alike. I used the example of mosquito species. Then the discussion turned to a consideration of the complexity involved in describing a niche. To realize this point, the students helped me construct niche descriptions on the overhead of an alley cat and a wild farm cat. Then an assignment was made for the students to construct niche descriptions for the next class period.

In an occasion during session 13, the niche as a description representation was picked up. There was discussion about how much one would need to know about an organism or a species in order to adequately describe the niche. Then a discussion ensued about niche as a dynamic rather than static state when I redirected the content with the question "Will the niches you have described be the same in forty years?" The representation at this point in the discourse was niche as a dynamic state. Then the representation changed again when I drew a diagram on the board of a person fishing from a bank of a lake. On this diagram were several organisms and also students advised me of all the relationships that one could depict in such a picture. After the diagram was quite full of lines and additions, the class took note of the complexity. I asked the class, while

pointing to a spot on the diagram, what the spot might be called. The majority of the students responded, "a niche." In response to another spot which I pointed out, the students referred to it as "a different niche." Thus, the representation of niche at this point was an intersection of cycles and relationships existing in a system. After that, a discussion was centered around adaptations and niches. This was accomplished by viewing and discussing the rather unusual adaptations evident on a picture of an imaginary "critter" that I had placed on the overhead projector.

In occasions during sessions 15 and 16, the notion of change in niches was considered during discourse and activities involving carrying capacity and humans' ability to alter it in the environment. Session 17 was an exam session. In one question, students had to use several terms in a description involving a perch in a lake in northern Minnesota. Niche was one term they were required to use in their descriptions. Also, some student responses to a question regarding lifestyles with respect to ecological guidelines included the construct, and in some cases, the actual term, niche.

The case of niche described above illustrates several of the patterns found across occasions as different pieces of content were tracked. These patterns are summarized below:

1. Representations of nearly all pieces of content increased in number across time and sessions.
2. Pieces of content became increasingly difficult to track as they became closely linked to representations of other pieces of content.

3. Exams and reviews often bottlenecked or narrowed the evolution of content.
4. Representations of related concepts and constructs often preceeded the formal, "expert" introduction of pieces of content.
5. Representations of content nearly always evolve from one "expert" form to multiple representations.

The case of niche does not clearly illustrate all the patterns identified in the larger study. However, it does show how multiple representations of content (i.e., niche) evolved across occasions and time. This was an especially predominant pattern in all cases of content constructed in the study. Further, it illustrates how a construct such as "roles" is linked to and preceeds introduction of formal representations of content. Figure 2 summarizes the various representations of content of niche, population change, and entropy as each evolved over the course of instruction. In parantheses are the sessions in which the occasions for each representation occurred.

CONCLUSIONS

The purpose of this study was to determine what representations of content existed in an environmental science class and what happened to those representations. In order to answer those questions, occasions for content in an experienced curriculum were analyzed.

The findings indicate that content, when studied in the contexts in which students experience it, was not an inert instructional variable. In this class, multiple representations

of pieces of content nearly always evolved over the course of instruction. The findings suggest that a dynamic nature of content can exist in an experienced curriculum. Therefore, assumptions about what the content is in a classroom may be vulnerable to much variation.

The results of this study do not generalize into broad claims about what ought or ought not happen to content. Rather, the findings suggest that content is not a "given" in this curriculum. If we wish to study content and what students learn about it, then attention must be given to the occasions in which students engage with it. An analytical focus on occasions may be one way of accomplishing the research task. Furthermore, attention to occasions for content may provide practicing teachers with opportunities for reflection and deliberation on the effectiveness of the curriculum occasions in their own classrooms.

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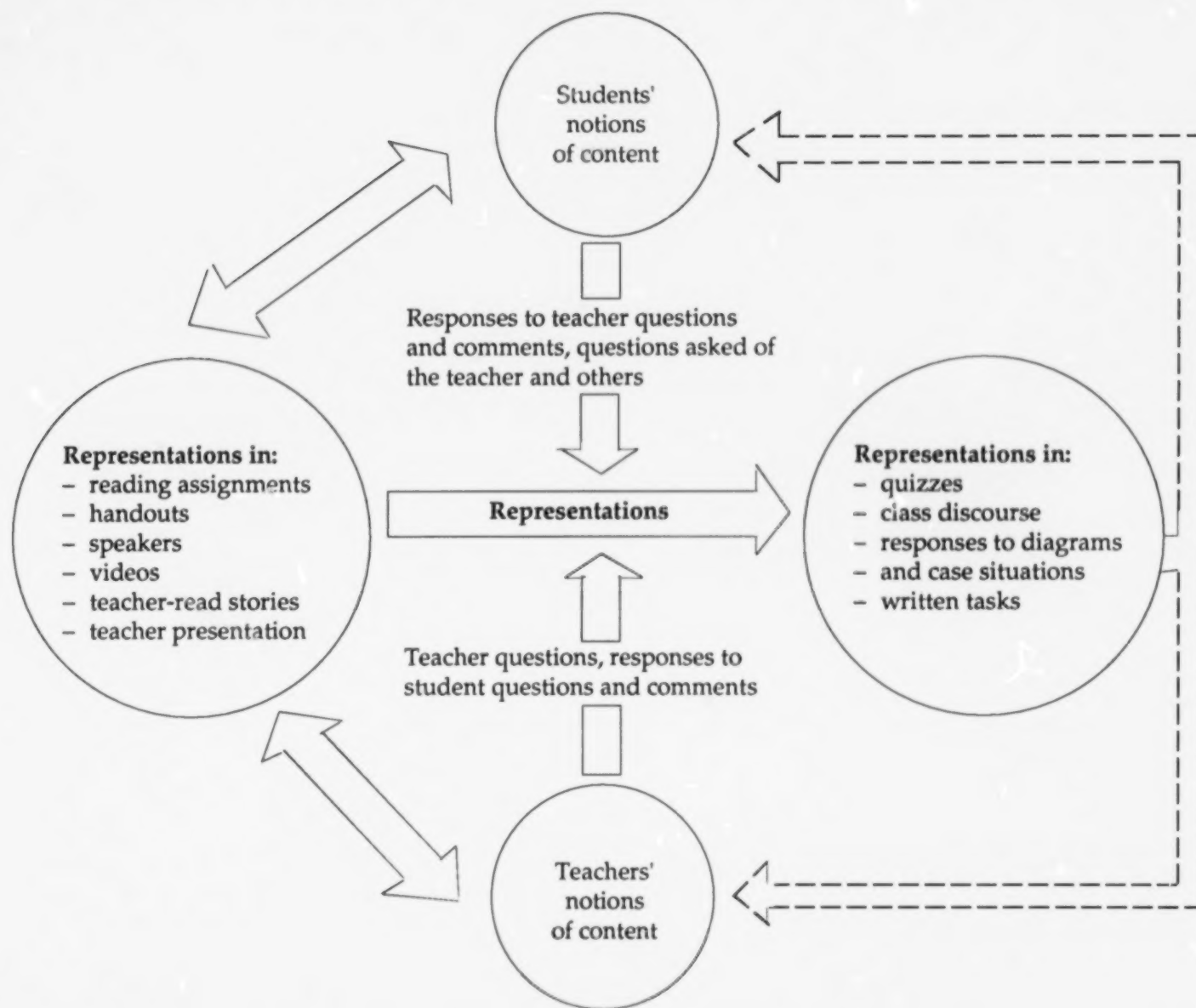


Figure 1. General Pattern of Content Evolution within Occasions for Content

Representations of Content: NICHE

- ROLE of humans in ecosystems (1,2,3,4,10)
- Impact of the human ROLE on the system (3,4,7,10)
 - ROLES and life choices (10,17)
- ROLES of organisms within systems (12,13)
- NICHE as the definition of a biological construct (12,13)
 - NICHE as a description (12,13,17)
 - NICHES as foci of competition (12,13)
- NICHES as the result of genetic variation (12)
 - NICHE as a complex state (12,13)
 - NICHE as a changeable state (13,15,16)

Representations of Content: POPULATION CHANGE

- Exponential GROWTH (2)
- History of CHANGE in human populations (2,4,9)
- Environmental philosophy and human population CHANGES (10)
 - Natural populations and STRESS (14,15,16,17)
- Populations and CHANGE: Natural Selection and Speciation (15,16)
 - Population CHANGE and genetic variation (16,17)
 - Population CHANGE and system simplification (16,17)

Representations of Content: ENTROPY

- Humans, resources, and waste INCREASE (4,5)
 - STATES of DISORDER (5,6)
 - Loss of USEFUL energy (6,7,9,10,12)
- ENTROPY as a definition of a scientific construct (6,9)
 - ENTROPY and recycling (6,11)
- Living things: Order from DISORDER (7,10)
 - Lifestyles and DISORDER (7,9,10,16,17)
 - Trade-offs and DISORDER (7,9,10,15,17)
 - DISORDER and system complexity (16,17)

Figure 2. Representations of Content during Class Sessions